



April 14, 2004

John L. Gross, Ph.D., P.E.  
Leader, Structures Group  
United States Department of Commerce  
National Institute of Standards and Technology  
Gaithersburg, MD 20899-0001

Dear Dr. Gross:

Following are responses to your questions in your letter to Joe Englot dated April 5, 2004, which are repeated here in bold italics.

***By this letter, I am requesting information from The Port Authority on fireproofing of the interior and exterior columns of the World Trade Center towers. Specifically, please provide the following:***

- 1) ***Fireproofing material and thicknesses for the exterior columns as follows:***
  - ***Plates 1 and 2 (these plates face the outside of the building and were covered by the aluminum column panels)***
  - ***Plate 3 (interior plate within the occupied space)***
  - ***Plate 4 (spandrel), both interior and exterior surfaces***
- 2) ***Fireproofing material and thicknesses for the core area box columns.***
- 3) ***Confirmation that the wide flange column sections were specified to be fireproofed as follows using Cafco Type DC/F:***
  - ***Columns smaller than 14WF228 – 2-3/16 in***
  - ***Columns greater than or equal to 14WF228 – 1-3/16 in.***

In response to your first three questions, Mr. Englot inquired throughout the Port Authority and was not able to find any information related to these questions other than that information already turned over to NIST.

- 4) ***Any information the Port Authority has regarding measurements of the in-place fireproofing material thickness.***

We have no records in our Materials Division of ever repairing or replacing fireproofing on exterior columns due to their inaccessibility and, therefore, have no recent thickness measurements of any re-applied fireproofing.



John L. Gross, Ph.D., P.E.  
National Institute of Standards and Technology  
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We have no records in our Materials Division of ever repairing or replacing fireproofing on core columns due to their inaccessibility (other than columns which are accessible within the elevator shafts) and, therefore, have no recent thickness measurements of any re-applied fireproofing for core columns.

The only records of thickness measurements we could find were for the columns that are accessible within the elevator shafts. The Port Authority Materials Engineering Division took them and they correspond to World Trade Center Tower 1 elevator shafts. Discrete readings were taken at shaft 10/11 from the basement to the 45<sup>th</sup> Floor in Tower 1 in a report dated 4/7/1999. Mean thickness values were found for shaft 14/15 from the basement to the 80<sup>th</sup> Floor in Tower 1 in a report dated 8/4/1997. These measurements cover the full extent of these two elevator shafts. One was an express from the concourse lobby to 44 with a machine room on 47 and the other was express from the concourse to 78 with an EMR on 81. The readings for both of these shafts are attached (Excel file).

Discussions with Engineering Department staff and former World Trade Department staff indicate that these two shafts had asbestos abatement and were re-fireproofed. The measurements also show a "Minimum Thickness Required" of fireproofing. Staff members recall that there was a schedule of replacement fireproofing thickness that was prepared by the firm Leslie E. Robertson Associates (LERA). One staff member located a copy of one schedule, which will be forwarded under separate cover as a sample. We have contacted William Faschan of LERA and it appears that the "Minimum Thickness Required" is the thickness called for in a schedule that appeared in documents for the work that was prepared by LERA. The sample schedule indicates that the fireproofing applied was "Type Z-106". We will try to locate the specification book for this material. This information may be among the documents that LERA assembled for NIST at the Port Authority's 225 Park Avenue South office. We will continue to search for more complete sets of this information.

In the meantime, I hope this answers your questions. Please call or reply otherwise if you need further information.

Very truly yours,

Francis J. Lombardi, PE  
Chief Engineer

Att.

Discrete Thickness Values  
Historical WTC Fireproofing  
Elevator Shaft Results

| Date of Report                    | 12/23/1993                    | 12/23/1993                    | 12/23/1993                    | 12/23/1993                   | 4/7/1999                            | 4/7/1999                | 4/7/1999                |
|-----------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------------|-------------------------|-------------------------|
| To:                               | J. Panebianco                 | J. Panebianco                 | J. Panebianco                 | J. Panebianco                | Eli Moscovitz                       | Eli Moscovitz           | Eli Moscovitz           |
| From:                             | S.M. Solomon                  | S.M. Solomon                  | S.M. Solomon                  | S.M. Solomon                 | Dorian Bailey                       | Dorian Bailey           | Dorian Bailey           |
| Building                          | 1WTC                          | 1WTC                          | 1WTC                          | 1WTC                         | 1 WTC                               | 1 WTC                   | 1 WTC                   |
| Floor                             | Elevator Shaft<br>12A/13A     | Elevator Shaft<br>12A/13A     | Elevator Shaft<br>12A/13A     | Elevator Shaft<br>12A/13A    | Elevator Shaft<br>10/11             | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 |
| Location/Test Area                | 78th Floor<br>Transverse Beam | 40th Floor<br>Transverse Beam | 20th Floor<br>Transverse Beam | 1st Floor<br>Transverse Beam | Columns<br>Basement to<br>1st Floor | Beams 1st<br>Floor      | Columns 2nd<br>Floor    |
| Minimum Thickness Required        | Not Cited                     | Not Cited                     | Not Cited                     | Not Cited                    | 0.50                                | 0.75                    | 0.50                    |
| <b>Reported Mean, inches</b>      | <b>1.50</b>                   | <b>1.00</b>                   | <b>0.65</b>                   | <b>0.60</b>                  | <b>0.88</b>                         | <b>1.06</b>             | <b>0.82</b>             |
| Discrete Gage #1                  | Discrete                      | Discrete                      | Discrete                      | Discrete                     | 1                                   | 1 1/4                   | 1                       |
| Discrete Gage #2                  | Measurements                  | Measurements                  | Measurements                  | Measurements                 | 3/4                                 | 1 1/4                   | 1                       |
| Discrete Gage #3                  | not available                 | not available                 | not available                 | not available                | 3/4                                 | 7/8                     | 7/8                     |
| Discrete Gage #4                  |                               |                               |                               |                              | 1                                   | 1 1/4                   | 5/8                     |
| Discrete Gage #5                  |                               |                               |                               |                              | 1 1/8                               | 3/4                     | 1/2                     |
| Discrete Gage #6                  |                               |                               |                               |                              | 1 1/8                               | 1 5/8                   | 5/16                    |
| Discrete Gage #7                  |                               |                               |                               |                              | 3/4                                 | 1                       | 1                       |
| Discrete Gage #8                  |                               |                               |                               |                              | 1 1/8                               | 1 1/8                   | 1                       |
| Discrete Gage #9                  |                               |                               |                               |                              | 1 1/8                               | 1                       | 1 1/8                   |
| Discrete Gage #10                 |                               |                               |                               |                              | 1                                   | 1 1/8                   | 1                       |
| Discrete Gage #11                 |                               |                               |                               |                              | 1                                   | 1 1/4                   | 3/4                     |
| Discrete Gage #12                 |                               |                               |                               |                              | 3/4                                 | 3/4                     | 7/8                     |
| Discrete Gage #13                 |                               |                               |                               |                              | 1 1/8                               | 5/8                     |                         |
| Discrete Gage #14                 |                               |                               |                               |                              | 5/8                                 | 1 1/8                   |                         |
| Discrete Gage #15                 |                               |                               |                               |                              | 5/8                                 | 1                       |                         |
| Discrete Gage #16                 |                               |                               |                               |                              | 1/2                                 | 1                       |                         |
| Discrete Gage #17                 |                               |                               |                               |                              | 7/8                                 |                         |                         |
| Discrete Gage #18                 |                               |                               |                               |                              | 5/8                                 |                         |                         |
| <b>Re-Calculated Mean, inches</b> |                               |                               |                               |                              | <b>0.88</b>                         | <b>1.06</b>             | <b>0.84</b>             |
|                                   |                               |                               |                               |                              |                                     |                         |                         |

Discrete Thickness Values  
Historical WTC Fireproofing  
Elevator Shaft Results

| Date of Report             | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                |
|----------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| To:                        | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           |
| From:                      | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           |
| Building                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   |
| Floor                      | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 |
| Location/Test Area         | Beams 2nd<br>Floor      | Columns 6th<br>Floor    | Beams 6th<br>Floor      | Columns 11th<br>Floor   | Beams 11th<br>Floor     | Columns 16th<br>Floor   | Beams 16th<br>Floor     | Columns 20th<br>Floor   |
| Minimum Thickness Required | 0.75                    | 0.50                    | 0.75                    | 0.50                    | 0.75                    | 0.50                    | 0.75                    | 0.50                    |
| Reported Mean, inches      | 0.93                    | 0.75                    | 0.97                    | 0.88                    | 0.93                    | 0.78                    | 0.94                    | 0.79                    |
| Discrete Gage #1           | 1 1/8                   | 3/4                     | 1                       | 3/4                     | 1                       | 3/4                     | 1                       | 7/8                     |
| Discrete Gage #2           | 7/8                     | 3/4                     | 1 1/4                   | 1                       | 1                       | 3/4                     | 3/4                     | 5/8                     |
| Discrete Gage #3           | 1 1/4                   | 5/8                     | 1 1/4                   | 11/16                   | 3/4                     | 1/2                     | 3/4                     | 7/8                     |
| Discrete Gage #4           | 7/8                     | 3/4                     | 1                       | 11/16                   | 1 1/8                   | 1/2                     | 1                       | 3/4                     |
| Discrete Gage #5           | 1 1/8                   | 1                       | 1 1/4                   | 1                       | 1                       | 3/4                     | 3/4                     | 1                       |
| Discrete Gage #6           | 3/4                     | 3/4                     | 1                       | 1                       | 7/8                     | 1                       | 7/8                     | 1                       |
| Discrete Gage #7           | 1                       | 3/4                     | 1                       | 1                       | 1                       | 7/8                     | 7/8                     | 1                       |
| Discrete Gage #8           | 1/2                     | 5/8                     | 5/16                    | 3/4                     | 3/4                     | 5/8                     | 1 1/4                   | 3/4                     |
| Discrete Gage #9           | 3/4                     | 3/4                     | 1                       | 5/8                     | 3/4                     | 5/8                     | 7/8                     | 5/8                     |
| Discrete Gage #10          | 3/4                     | 5/8                     | 3/4                     | 1                       | 1                       | 1/2                     | 1 1/8                   | 5/8                     |
| Discrete Gage #11          | 1                       | 3/4                     | 1                       | 3/4                     | 15/16                   | 5/8                     | 1 1/8                   | 3/4                     |
| Discrete Gage #12          | 3/4                     | 1                       |                         | 3/4                     |                         | 1                       | 1                       | 3/4                     |
| Discrete Gage #13          |                         | 5/8                     |                         | 3/4                     |                         | 1                       | 1                       | 5/8                     |
| Discrete Gage #14          |                         | 3/4                     |                         | 5/8                     |                         | 7/8                     |                         |                         |
| Discrete Gage #15          |                         |                         |                         | 5/8                     |                         | 1                       |                         |                         |
| Discrete Gage #16          |                         |                         |                         |                         |                         | 7/8                     |                         |                         |
| Discrete Gage #17          |                         |                         |                         |                         |                         |                         |                         |                         |
| Discrete Gage #18          |                         |                         |                         |                         |                         |                         |                         |                         |
| Re-Calculated Mean, inches | 0.90                    | 0.75                    | 0.98                    | 0.80                    | 0.93                    | 0.77                    | 0.95                    | 0.79                    |
|                            |                         |                         |                         |                         |                         |                         |                         |                         |

Discrete Thickness Values  
Historical WTC Fireproofing  
Elevator Shaft Results

|                                   |                         |                         |                         |                         |                         |                         |                         |                         |
|-----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Date of Report                    | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                | 4/7/1999                |
| To:                               | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           |
| From:                             | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           | Dorian Bailey           |
| Building                          | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   |
| Floor                             | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 |
| Location/Test Area                | Beams 20th<br>Floor     | Columns 25th<br>Floor   | Beams 25th<br>Floor     | Columns 30th<br>Floor   | Beams 30th<br>Floor     | Columns 35th<br>Floor   | Beams 35th<br>Floor     | Columns 41th<br>Floor   |
| Minimum Thickness Required        | 0.75                    | 0.50                    | 0.75                    | 0.50                    | 0.75                    | 0.50                    | 0.75                    | 0.50                    |
| <b>Reported Mean, inches</b>      | <b>1.07</b>             | <b>0.87</b>             | <b>0.96</b>             | <b>0.88</b>             | <b>0.93</b>             | <b>0.80</b>             | <b>0.97</b>             | <b>0.92</b>             |
| Discrete Gage #1                  | 1 1/8                   | 15/16                   | 3/4                     | 1 1/2                   | 1 1/8                   | 1 1/8                   | 1 1/4                   | 1                       |
| Discrete Gage #2                  | 1                       | 1                       | 1                       | 1                       | 1                       | 1                       | 3/4                     | 3/4                     |
| Discrete Gage #3                  | 1 1/4                   | 31/32                   | 3/4                     | 1                       | 7/8                     | 5/8                     | 1 1/8                   | 3/4                     |
| Discrete Gage #4                  | 1                       | 1                       | 1 3/8                   | 1                       | 15/16                   | 15/16                   | 1                       | 3/4                     |
| Discrete Gage #5                  | 3/4                     | 1 1/4                   | 1 1/4                   | 7/8                     | 1 1/4                   | 3/4                     | 1 1/4                   | 1                       |
| Discrete Gage #6                  | 7/8                     | 1 1/8                   | 7/8                     | 3/4                     | 1 1/4                   | 1                       | 1 1/4                   | 7/8                     |
| Discrete Gage #7                  | 1 1/8                   | 3/4                     | 1                       | 7/8                     | 7/8                     | 7/8                     | 3/4                     | 1                       |
| Discrete Gage #8                  | 1                       | 3/4                     | 3/4                     | 3/4                     | 3/4                     | 7/8                     | 7/8                     | 1                       |
| Discrete Gage #9                  | 7/8                     | 1                       | 7/8                     | 1                       | 3/4                     | 3/4                     | 7/8                     | 1                       |
| Discrete Gage #10                 | 15/16                   | 1                       | 1 1/4                   | 3/4                     | 7/8                     | 1/2                     | 3/4                     | 1                       |
| Discrete Gage #11                 | 7/8                     | 1                       | 3/4                     | 7/8                     | 3/4                     | 5/8                     | 3/4                     |                         |
| Discrete Gage #12                 | 1 1/8                   | 1/2                     | 1                       | 1/2                     | 15/16                   | 1                       | 7/8                     |                         |
| Discrete Gage #13                 | 1                       | 7/8                     | 3/4                     | 3/4                     | 5/8                     | 1/2                     | 1                       |                         |
| Discrete Gage #14                 | 1                       |                         |                         | 1/2                     | 3/4                     | 1/2                     |                         |                         |
| Discrete Gage #15                 |                         |                         |                         | 15/16                   |                         | 1/2                     |                         |                         |
| Discrete Gage #16                 |                         |                         |                         |                         |                         |                         |                         |                         |
| Discrete Gage #17                 |                         |                         |                         |                         |                         |                         |                         |                         |
| Discrete Gage #18                 |                         |                         |                         |                         |                         |                         |                         |                         |
| <b>Re-Calculated Mean, inches</b> | <b>1.00</b>             | <b>0.94</b>             | <b>0.95</b>             | <b>0.87</b>             | <b>0.91</b>             | <b>0.77</b>             | <b>0.96</b>             | <b>0.91</b>             |
|                                   |                         |                         |                         |                         |                         |                         |                         |                         |

Discrete Thickness Values  
Historical WTC Fireproofing  
Elevator Shaft Results

| Date of Report             | 4/7/1999                | 4/7/1999                | 8/4/1997                 | 8/4/1997                | 8/4/1997                | 8/4/1997                | 8/4/1997                |
|----------------------------|-------------------------|-------------------------|--------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| To:                        | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz            | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           | Eli Moscovitz           |
| From:                      | Dorian Bailey           | Dorian Bailey           | John Bullard             | John Bullard            | John Bullard            | John Bullard            | John Bullard            |
| Building                   | 1 WTC                   | 1 WTC                   | 1 WTC                    | 1 WTC                   | 1 WTC                   | 1 WTC                   | 1 WTC                   |
| Floor                      | Elevator Shaft<br>10/11 | Elevator Shaft<br>10/11 | Elevator Shaft<br>14/15  | Elevator Shaft<br>14/15 | Elevator Shaft<br>14/15 | Elevator Shaft<br>14/15 | Elevator Shaft<br>14/15 |
| Location/Test Area         | Beams 41th<br>Floor     | Columns 45th<br>Floor   | Basement to<br>5th Floor | 5th to 20th<br>Floor    | 20th to 54th<br>Floor   | 54th to 68th<br>Floor   | 68th to 80th<br>Floor   |
| Minimum Thickness Required | 0.75                    | 0.50                    | 0.50                     | 0.50                    | 0.50                    | 0.63                    | 0.88                    |
| Reported Mean, inches      | 1.01                    | 0.75                    | 0.75                     | 0.80                    | 0.85                    | 0.90                    | 1.00                    |
| Discrete Gage #1           | 1 1/4                   | 5/8                     | Discrete                 | Discrete                | Discrete                | Discrete                | Discrete                |
| Discrete Gage #2           | 1                       | 5/8                     | Measurements             | Measurements            | Measurements            | Measurements            | Measurements            |
| Discrete Gage #3           | 1 1/4                   | 7/16                    | not available            | not available           | not available           | not available           | not available           |
| Discrete Gage #4           | 1 1/4                   | 5/8                     |                          |                         |                         |                         |                         |
| Discrete Gage #5           | 1 1/4                   | 5/8                     |                          |                         |                         |                         |                         |
| Discrete Gage #6           | 1                       | 5/8                     |                          |                         |                         |                         |                         |
| Discrete Gage #7           | 1/2                     | 1                       |                          |                         |                         |                         |                         |
| Discrete Gage #8           | 1/2                     | 1                       |                          |                         |                         |                         |                         |
| Discrete Gage #9           | 1                       | 7/8                     |                          |                         |                         |                         |                         |
| Discrete Gage #10          | 1                       | 1                       |                          |                         |                         |                         |                         |
| Discrete Gage #11          | 1                       |                         |                          |                         |                         |                         |                         |
| Discrete Gage #12          | 7/8                     |                         |                          |                         |                         |                         |                         |
| Discrete Gage #13          |                         |                         |                          |                         |                         |                         |                         |
| Discrete Gage #14          |                         |                         |                          |                         |                         |                         |                         |
| Discrete Gage #15          |                         |                         |                          |                         |                         |                         |                         |
| Discrete Gage #16          |                         |                         |                          |                         |                         |                         |                         |
| Discrete Gage #17          |                         |                         |                          |                         |                         |                         |                         |
| Discrete Gage #18          |                         |                         |                          |                         |                         |                         |                         |
| Re-Calculated Mean, inches | 0.99                    | 0.74                    |                          |                         |                         |                         |                         |

## DOCUMENT DATA FORM

Your Name: Nick Carino

Document Title or Description (max. 254 characters): Circle: Same as cover (or fill in below)

Letter Lombardi to NIST regarding fire protection of columns

Include work order no. and floor no. if applicable

Roll #:

Doc. ID (report #, dwg. #):

Document Date:

April 14, 2004

Document Author Name:

Frank Lombardi

Author Organization:

PA NY/NJ

## KEYWORDS - HIGHLIGHT ALL THAT APPLY

## Level 1

|                       |                          |                           |
|-----------------------|--------------------------|---------------------------|
| Bankers Trust         | Project 5                | WTC 3 - Marriot Hotel     |
| Below Grade           | Project 6                | WTC 4 - South Plaza Bldg. |
| Concourse             | Project 7                | WTC 5 - North Plaza Bldg. |
| Electrical Substation | Project 8                | WTC 6 - Customs House     |
| Liberty Plaza         | WFC 1 - Oppenhiemer Dow  | WTC 7                     |
| PATH Station          | WFC 2 - Tower B          | WTC Complex               |
| Project 1             | WFC 3 - American Express | WTC Plaza                 |
| Project 2             | WFC 4 - Tower D          |                           |
| Project 3             | WTC 1 - North Tower      | Add                       |
| Project 4             | WTC 2 - South Tower      |                           |

## Level 2

|                          |                 |                            |                    |
|--------------------------|-----------------|----------------------------|--------------------|
| Accident analysis & risk | Fire protection | Misc. Performance Problems | Tenant alterations |
| Architectural            | Fire service    | News coverage              | Tenant Space       |
| Data request             | Landscaping     | Police                     | Add                |
| Emergency management     | Management      | Security                   |                    |
| Evacuation               | Mech./elec.     | Structural                 |                    |

## Level 3

|                       |                          |                             |                   |
|-----------------------|--------------------------|-----------------------------|-------------------|
| 1993 explosion        | Deck                     | Hat truss                   | Shop drawings     |
| A/E fitout            | Deflection               | Human comfort               | Shortening        |
| A-242                 | Demolition               | HVAC                        | Slab              |
| A-36                  | Design                   | Index                       | Slurry wall       |
| A-497                 | Detailing                | Inspection                  | Smoke control     |
| Aircraft impact       | Doors                    | Insulation                  | Smoke test        |
| Air cooled condensers | Drawings                 | Job number                  | Spandrel beam     |
| Analysis              | Eastern States Steel     | Joist                       | Specifications    |
| Angles                | Egress                   | L-50                        | Splices           |
| Antenna               | Elevator                 | Lighting                    | Sprinkler         |
| Artifacts             | Emergency communications | Loads                       | Stability         |
| Asbestos              | Equipment                | Maintenance                 | Stairways         |
| Base plate            | Erection marks           | Marking                     | Standards         |
| Beams                 | Escalator                | Mesh reinforcement          | Steel             |
| Bid Invitation        | Expansion joint          | Mill inspection             | Steel composition |
| Bow tie               | Exterior columns         | Model                       | Stiffness         |
| Bracing               | Fabrication              | Mullion                     | Structural review |
| Bridging truss        | Family member            | Operations                  | Survivor          |
| Calculations          | Field survey             | Paint                       | Tenant list       |
| Carpet                | Fire alarms              | Partition layout            | Testing           |
| Ceilings              | Fireproofing             | Partitions                  | Tie               |
| Certification         | Fire spread              | Photos                      | Tolerances        |
| Chillers              | Fire testing             | Pipes                       | Transfer Girders  |
| Cladding              | Flag Pole                | Plumbing                    | Triad             |
| Collapse              | Flammability             | Prestressing                | Truss             |
| Columns               | Floor                    | Probability, uncertainty    | Vestibule         |
| Communication systems | Floor load               | Quality control             | Vibration         |
| Composite truss       | Floor slab               | Ramp                        | Walls             |
| Computer output       | Floor system             | Reinforcing (strengthening) | Water supply      |
| Computer program      | Floor trusses            | Renovation                  | Weather           |
| Concrete              | Foundations              | Repair                      | Weight            |
| Connections           | Fracture                 | Research & Development      | Weld detail       |
| Construction          | Frame                    | Roof                        | Weld size         |
| Contract              | Frame analysis           | Safety                      | Welding           |
| Core beams            | Frequency                | Schedule                    | Wind              |
| Core columns          | Fuel                     | Sculpture                   | Windows           |
| Cranes                | Furniture layout         | Security system             | Yield strength    |
| Criteria              | H Generators             | Shear knuckle               |                   |
| Dampers               | Guidelines               | Shear test                  | Add               |
| Debris                | Gypsum board             | Shear Stud                  |                   |